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Economic baselines for emerging IPDM measures (projects AL16009 and AL16005)

- *Agriculture Victoria Research quantified the benefits and costs of current grower practices for controlling or suppressing hull rot, trunk disease (phytophthora), carpophilus beetle and carob moth.*
- *The data collected, the budgets built and findings are a baseline for future economic evaluations of alternative integrated pest and disease management measures.*
- *The scope of operations and the resources available on three large corporate or family-run orchards from the SA Riverland, Vic Sunraysia and NSW Riverina were examined in detail.*
- *Costs were estimated with some certainty. By contrast, pest and disease impacts were very uncertain. So, a range of net farm-level benefits was estimated for each operation on each participating orchard.*
- *In most cases, it pays well for growers to take action. The one exception was the higher-cost control measure for hull rot.*
- *Hygiene for the control of carpophilus beetle and carob moth was assessed jointly and was the most positive of all the pest and disease control measures examined.*

Introduction

On projects AL16009 and AL16005, Agriculture Victoria Research (AVR) conducted an economic analysis to provide "baselines" against which emerging Integrated Pest and Disease Management (IPDM) measures could be compared.

Pests of interest were carpophilus beetle (CB) and carob moth (CM). Diseases of interest were hull rot (HR) and trunk disease (TD) (phytophthora).

In the short-term, growers incur quality losses and/or yield losses. In the longer-term losses may occur because of tree decline and ultimately death.

The economic analysis involved quantifying the farm-level benefits and costs of current practices to control or suppress these pests and diseases. Practices included spray programs and orchard hygiene.

Three key elements

The economic analysis comprised three elements.

- First, involvement of scientists working on the projects for advice on pest and disease impacts and

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the effectiveness of various control measures.

- Second, consultation with several technical/operations managers from large corporate or family-run orchards from the SA Riverland, Vic Sunraysia and NSW Riverina, who generously shared detailed knowledge about their current practices and likely outcomes.
- Third, risk budgeting, using conventional farm management analysis principles, to obtain a most likely value and range of the net benefits for each operation on each participating orchard.

Economic performance metrics

The net benefits to growers of each control measure were measured in two ways:

1. Net benefits (NB). This metric is the $A/ha-value of total losses (economic 'damages') without control (F_B) LESS the damages with control (F_C), LESS the total costs of the control measure (TC). If the NB > 0, then the control is worth undertaking.

$$NB = F_B - F_C - TC$$

2. Benefit cost ratio (BCR). This is the $A/ha-value of damages without control LESS the value of damages with control, all DIVIDED BY the costs of each control measure. A BCR > 1 means the control measure is worth undertaking.

$$BCR = \frac{(F_B - F_c)}{TC}$$

Benefit items

Assumptions about impacts of the pests and diseases on kernel yields and quality, and tree deaths are shown in Table 1. Impacts are shown without and with control measures.

These estimates were informed by scientific and grower opinion. They were highly uncertain, so broad ranges are given.

Table 1. Assumed pest and disease impacts

Pest/ disease	Uncontrolled	Controlled
Hull Rot	2-3% yield loss per annum	1-2%
Trunk diseases including *Phytophthora*	A total of ~10 tree deaths per hectare by the end of the productive life of the orchard (25 years)	A total of ~ 4 tree deaths per hectare
Carpophilus beetle	10-20% kernel damage per annum	2%
Carob moth	3-5% kernel damage per annum	2%

Subsequent damages in $/ha terms were estimated as follows:

- Yield losses were valued at $A 6.8/kg kernel (in the range $5.4 to $7.6), this being the average

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of real prices over the 5-years to 2021.

- Tree density was assumed to be 286 trees/ha and yield potential 3.8t kernel/ha (in the range 2.5t to 5.0t).
- Longer-term yield losses from TD were evaluated over the productive life of the representative orchard (25 years) using a 5% (real) discount rate. Diseased trees were assumed to decline gradually over 5 to 7 years, at which time they were removed and not replaced.
- Market discounts for quality defects and higher grading fees were used to value kernel damage. Quality impacts of HR were not considered, as infected nuts were assumed to be "cracked out" (not sold in-shell). By contrast, insect damage is a "serious" defect and the portion of the consignment damaged by insects did not receive any return. Furthermore, if insect damage was present, progressively higher grading fees were applied to the whole consignment (e.g., 15 c/kg kernel if 5% affected).

Cost items

Grower actions and the resources available to them vary, so the costs of operations also varied between respondents.

Costs included those for agri-chemicals. They also include machinery ownership costs ("fixed" costs) which occur regardless of whether the machine is used, and "variable" operating costs that are proportional to machinery usage (labour, fuel and lubricants). Timeliness costs, which are the costs associated with failure to perform operations in timely ways, were not considered.

Spraying to suppress HR involved one foliar application around hull split of Luna Sensation® (Fluopyram + Trifloxystrobin), Merivon® (Pyraclostrobin + Fluxapyroxad) or Custodia® (Tebucanazole + Azoxystrobin).

Treatment to suppress TD involved spraying and/or chemigation with phosphonates. Chemigation involved applying the fungicide through the drip line. Application may include a mandatory single spray every year, a spray followed by a chemigation after hull split, or two chemigations in September and late November.

Sprays were not normally used against insect pests, with respondents preferring to focus on good orchard hygiene to destroy overwintering sites for CB and CM. Good orchard hygiene involved shaking mummy nuts from the trees, sweeping the nuts into the mid rows and then destroying them by mulching. These activities were done in either two or three separate passes.

The base-line costings for orchard hygiene were based on going through the orchard once; but two or more times may be required if pest pressure is high. The cost of re-harvesting was not included because any re-harvested nuts were sold with the income reportedly covering costs.

Results

Hull Rot

Table 2 shows the NB and BCR of spraying for HR suppression using the two different approaches reported by our growers. Also shown in the table is the times each option was worthwhile compared to doing nothing, i.e., the times the NB > 0 or the BCR >1.

Table 2. Average annual net benefits accruing to individual growers of spraying for hull rot ($/ha[a]).

Damages without control	Damages with control	Material costs[b]	Machinery ownership costs[c]	Machinery operating costs[d]	Total costs	Net benefits (NB)	Benefit cost ratio (BCR)	Times control is the best option (%)
Option 1: One spray at hull split; lower operation costs and a less expensive fungicide								
610	366	52	13	45	110	134	2.2	96
Option 2: One spray at hull split, higher operation costs and a more expensive fungicide								
610	366	180	30	55	265	-21	0.9	37

a. *Units are $/ha unless otherwise stated*
b. *Material costs are for sprays at label rate and wetters (if required).*
c. *Machinery ownership costs are the annualised capital recovery cost plus repairs and maintenance plus insurance and housing.*
d. *Machinery operating costs include labour, fuel and lubricants.*

Both options involved one spray at hull split; but option 1 had lower operation costs and a less expensive fungicide than the other. Because of the considerable uncertainty in estimating the disease impact on yield, damages were assumed to be similar (in the range shown in Table 1) regardless of the treatment option used.

The NB of spraying for HR was mixed depending on the approach used. Total costs ranged from $110/ha to $265/ha, of which sprays (at label rate) range from a low of $52/ha to a high of $180/ha. Higher costs resulted in a NB of -$21/ha indicating the costs of control exceeded the economic damages caused by the disease. However, the lower-cost option provided a NB of $134/ha. The BCR ranged from an undesirable 0.9 to a desirable 2.2.

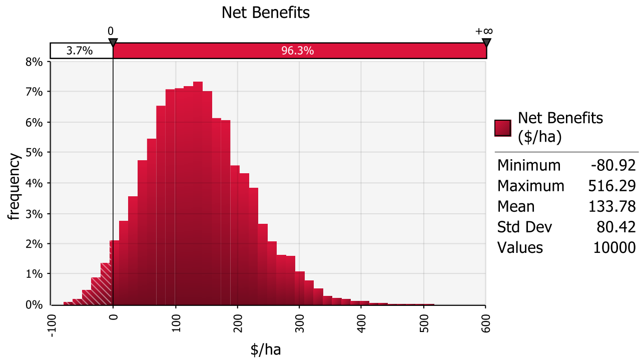

Figure 1a. Distribution of net benefits from hull rot suppression: option 1 (lower cost option).

Reflecting uncertainty about disease impacts, and the riskiness in kernel prices and yields, the range in NB for the least-cost option (option 1) is shown in Figure 1a as a bell curve. The bar at the top of the figure shows the probability of breaking even, in other words the times out of 100 that the work done to control the disease was worthwhile in economic terms (i.e., NB > 0). In this case, 96% of the time

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it would pay the grower to treat for HR rather than do nothing.

Variation in the NB was most sensitive to uncertainty about yield losses with and without the control. This is shown by the greater width of the top two bars in Figure 1b.

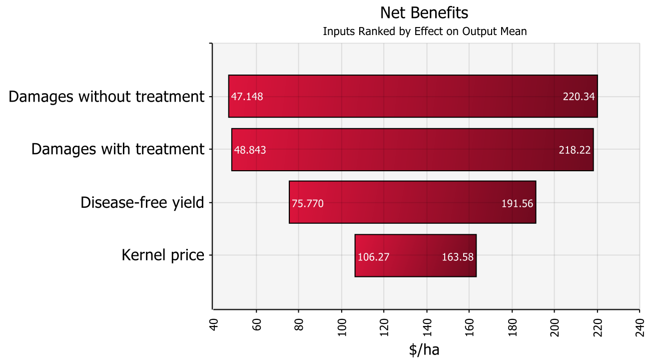

Figure 1b. Sensitivity of net benefits from hull rot suppression to risky or uncertain variables: option 1 (lower cost option).

Trunk Disease

Table 3 shows the NB and BCR of spraying and/ or chemigation for TD suppression. These actions provided a positive economic benefit to growers for all three treatment options.

Total costs ranged from $50/ha for option 1 (which involved two chemigations, one in September and another in late November) to $136/ha (which involved one spray followed by a chemigation after hull split).

Table 3. Average annual net benefits accruing to individual growers of spraying and/ or chemigation for trunk disease ($/ha[a]).

Damages without control	Damages with control	Material costs[b]	Machinery ownership costs[c]	Machinery operating costs[d]	Total costs	Net benefits (NB)	Benefit cost ratio (BCR)	Times control is the best option (%)
Option 1: Two chemigations, one in September and another in late November								
405	155	50			50	200	5.0	100
Option 2: One single spray every year								
405	155	25	13	45	83	167	3.0	100
Option 3: One spray followed by a chemigation after hull split								
405	155	50	31	55	136	114	1.8	99

a. Units are $/ha unless otherwise stated

b, c, d, as per Table 1

The expected NB ranged from $114/ha to $200/ha, the BCR was upward of 1.8 and positive 99% to 100% of times (see also Figure 2a).

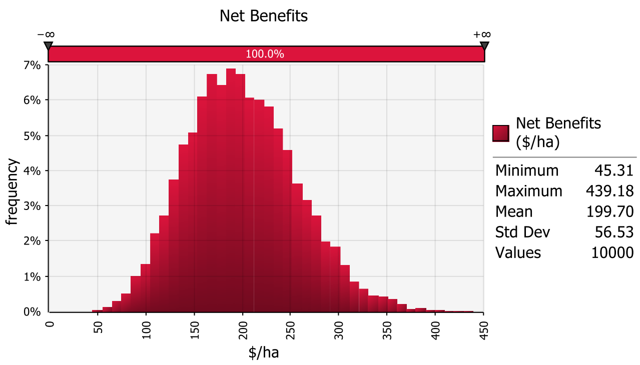

Figure 2a. Distribution of net benefits from trunk disease suppression: chemigation activities (option 1).

Results were most sensitive to uncertainty about tree deaths without treatment (Figure 2b).

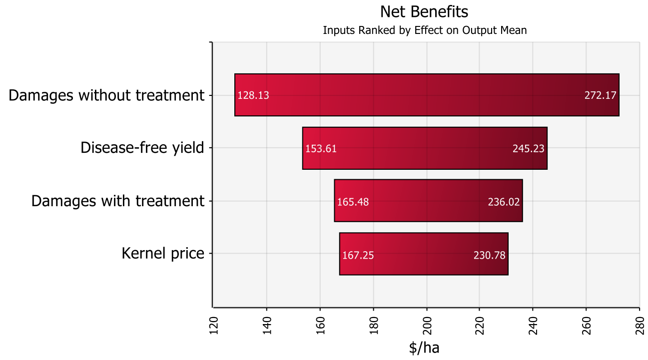

Figure 2b. Sensitivity of net benefits from trunk disease suppression to risky/ uncertain variables: chemigation activities (option 1).

Carpophilus Beetle and Carob Moth

Table 4 shows the NB and BCR for orchard hygiene to control CB and CM using three different approaches.

Table 4. Average annual net benefits accruing to individual growers from orchard hygiene to control carpophilus beetle and carob moth ($/ha[a]).

Damages without control	Damages with control	Material costs[b]	Machinery ownership costs[c]	Machinery operating costs[d]	Total costs	Net benefits (NB)	Benefit cost ratio (BCR)
Option 1: No re-shaking. Two separate passes. One pass with self-propelled sweeper. Another pass with 'Terminator' bolted to conditioner.							
4,414	986	112	118	230	3,198	14.9	100
Option 2: One pass re-shaking. A second pass with V-sweeper, flail mulcher and blower arranged in tandem.							
4,414	986	203	131	335	3,093	10.2	100
Option 3: Three separate passes for re-shaking, V-sweeping, and finally mulching with an FAE mulcher.							
4,414	986	271	217	488	2,940	7.0	100

b. Units are $/ha unless otherwise stated

b, c, d, as per Table 1

One grower sweeps and blows in one pass and then mulches with an FAE mulcher in a second pass (option 3). One grower sweeps, mulches with a flail mower, and blows all in one pass, as shown in the picture (option 2). Another sweeps in one pass, and destroys mummy nuts with a 'terminator' in a second pass (option 1).

Figure 4. sweeping, flail mulching and blowing all in one pass to destroy overwintering mummy nuts and remove them from the drip line

The economic advantage of these measures was the greatest of all the pest and disease control options examined. This was due to substantial economic damages resulting from uncontrolled infestations, estimated at over $4,400/ha.

The costs of machinery ownership and operation (labour, fuel, lubricants) were also high, ranging from $230/ha to $488/ha. The NB ranged from $3,195/ha to $2,940/ha. The BCR was extremely positive under all scenarios, exceeding 7.0.

Should costs double in those instances where the grower needed to get through the orchard twice because of high pest pressure, the NB would drop to $2,968/ha for option 1, and the BCR would halve to 7.5.

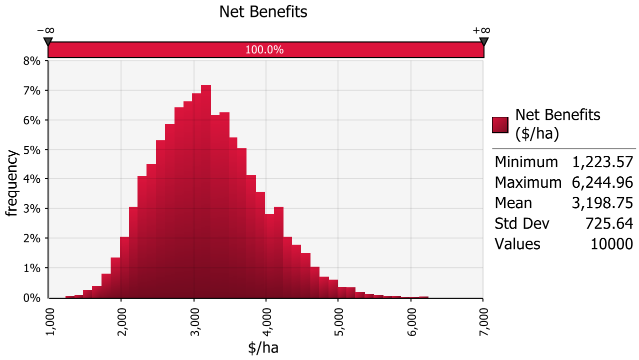

Figure 4a. Distribution of net benefits from control of carpophilus beetle and carob moth: least-cost orchard hygiene activities (option 1).

Outcomes were positive 100% of times (Figure 4a), and most sensitive to assumptions about the size of uncontrolled damages and the yield potential (Figure 4b).

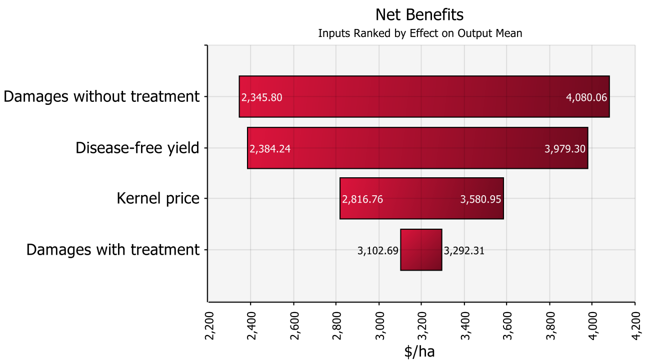

Figure 4b. Sensitivity of net benefits from control of carpophilus beetle and carob moth to risky/ uncertain variables: least-cost orchard hygiene activities (option 1).

Conclusions

The data collected and the risk budgets built for this analysis were used to quantify the NB and BCR for control of priority pests and diseases of almond. Operations relevant to AVR activities were current spray programs to suppress HR and TD and orchard hygiene for the control of CB and CM. Except for the higher-cost HR option, all were found to be economically beneficial compared to doing nothing, regardless of the specific actions taken by growers, and the different resources available to them.

Estimates of economic benefits were very sensitive to the considerable uncertainty surrounding pest and disease impacts on kernel quality and yields, and tree decline and death. Because of this sensitivity, research into emerging IPDM measures should measure not only the incidence and severity of disease, but also the impact on kernel yield and quality, tree decline and death.

There is scope for emerging IPDM measures to be cost advantageous because of the high operating costs involved in current practices. The data collected and the risk budgets built for this analysis will be integral to economic evaluations of emerging IPDM measures going forward.

For further information about projects AL16009 and AL16005 led by Agriculture Victoria please visit **https://www.horticulture.com.au/growers/help-your-business-grow/**

This project has been funded by Hort Innovation using the almond research and development levy and funds from the Australian Government. For more information on the fund and strategic levy investment visit horticulture.com.au